

THE GENUS *ZEMIRA* H. and A. ADAMS (MOLLUSCA: NEOGASTROPODA)

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Plates 7-8

SUMMARY

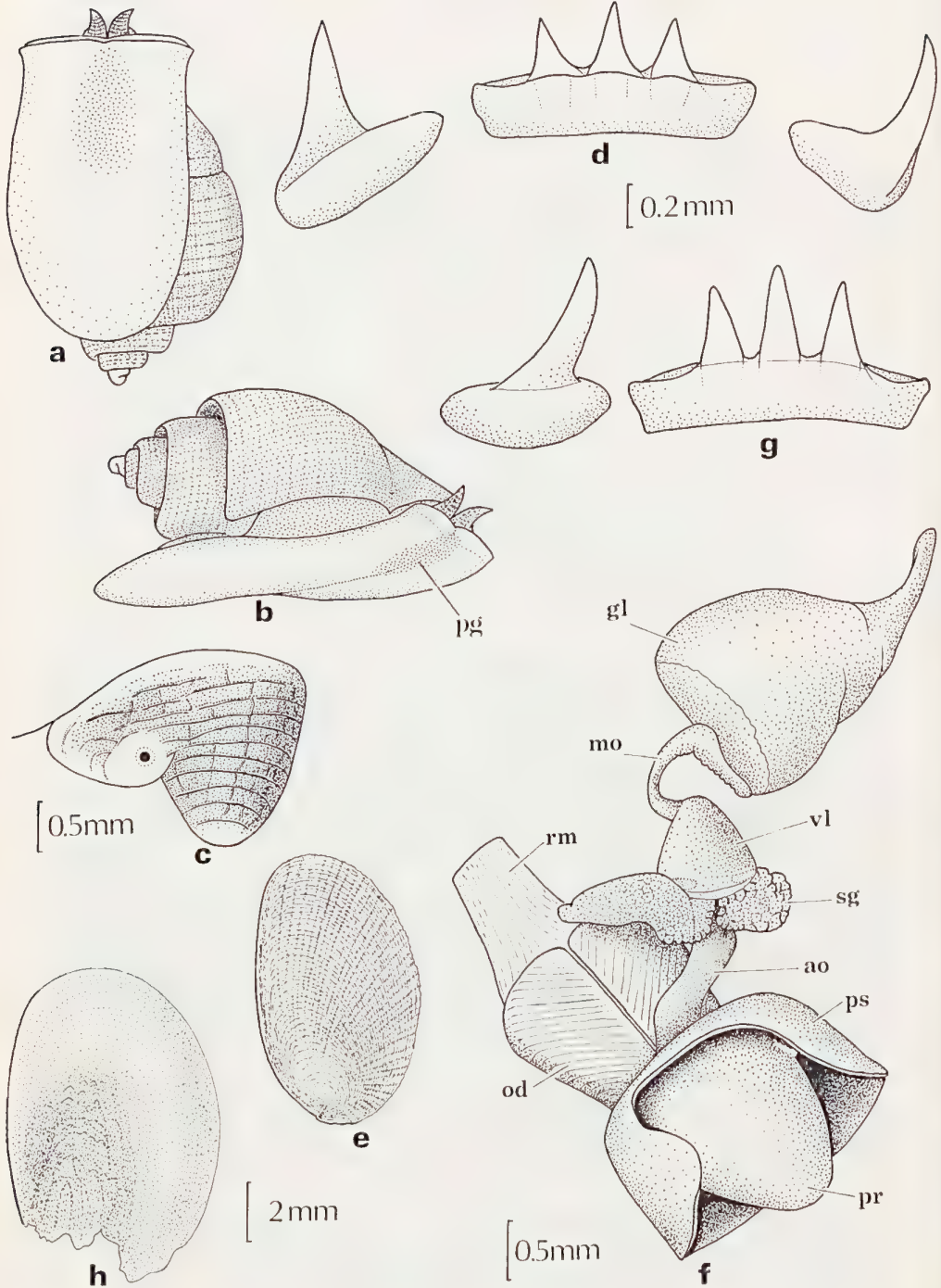
From a study of the anatomy and stratigraphic history of *Zemira* it is concluded that the genus can tentatively remain in the Pseudolivinae of the Olividae, where it has usually been placed by recent authors. *Zemira* differs from other members of the Olividae in having a simple foot, in not having an elongated anterior siphon and in lacking accessory salivary glands. *Eburnopsis* Tate is a synonym of *Zemira* Adams & Adams and *Z. praecursoria* Tate and *Eburnopsis aulacoessa* Tate are synonyms of *Z. australis australis* (G. B. Sowerby 1). *Z. australis antecursoria* subsp. nov. (Lower Miocene) is described. The other species included in the genus are *Z. tessellata* (Tate) and *Z. bodalla* Garrard.

INTRODUCTION

The taxonomic position of *Zemira australis* (G. B. Sowerby 1, 1833) has been the subject of some debate. Hedley (1899) and Cooke (1918) have each devoted a paper to the subject and reference can be made to these for a detailed history of the early taxonomic confusion surrounding this gastropod. Suffice to say that this species has been variously placed in the Buccinidae, the Cancellariidae, the Struthiolariidae, the Muricidae and the Olividae. Cooke (1918) was the first to describe the radula which he concluded was close to that of *Murex* and he suggested placing *Zemira* "near to *Murex*". Iredale (1924) suggested that *Zemira* deserved family rank on the basis of Cooke's conclusions, and should be placed next to the Olividae, and the Zemiridae is also used by Iredale and McMichael (1962), although they place the family next to Struthiolariidae in the Mesogastropoda. Thiele (1929) and Wenz (1941) both place *Zemira* and *Eburnopsis* in the Pseudolivinae, a subfamily of the Olividae, although Cossmann (1901) placed this subfamily in the Buccinidae.

The following account is based on a study of Recent and fossil shells and of a few living and preserved specimens of *Z. australis* obtained on the continental shelf off Sydney. The anatomical results are based on observations on living animals and on dissections. No histological studies have been made.

The object of the study is to provide some basic anatomical information about *Zemira australis* and information on fossil species to try and determine the correct taxonomic position of the genus *Zemira*. All fossil localities are in Victoria, unless otherwise indicated.



Zemira

ANATOMICAL DESCRIPTION

Material examined: *Zemira australis* (Sowerby). 7 specimens, dredged off Malabar, S. of Sydney, N.S.W., in 66 m, 26 March, 1973, medium to fine sandy-mud. 1 specimen, North Head, Sydney, in 82 m, 30 May, 1973, medium to coarse sand.

Zemira bodalla Garrard. 1 specimen, dried animal of holotype (a female).

Pseudoliva crassa (Gmelin). One partially dissected specimen, Port Alexander, West Africa, 7 October, 1912. Held by Museum für Naturkunde, E. Berlin.

Melapium elatum (Schubert and Wagner). One animal, trawled off Xai-Xai, Mozambique, in 100 m, 15 September 1973, collected C. P. Fernandes. Animal held by Natal Museum, S. Africa.

Zemira australis and *Z. bodalla*.

Head-foot. (Text figures 1 and 2.) The head bears a pair of short, broad, flattened tentacles (t) which have flat, expanded lobes (cl) at their outer bases (fig. 1c) bearing the small eyes. There is no snout, the rhyncostome opening deep between the closely applied tentacles. The only pigmentation on the head-foot is on the tentacles, this being horizontal streaks of black, these denser along the inner margins of the tentacles. The remainder of the head-foot is white to yellowish-white.

The foot (fig. 1a, 1b) is rather short, broad, and rather thin. There are no dorsal outgrowths nor is there any indication of a transverse groove in the anterior part of the foot as is normally encountered in the Olividae. The sole has a median, denser, pale yellowish area (pg) in the anterior half. This area was frequently observed to contract to form a deep, steep-sided groove running to the anterior margin, or separate, deep hollows. This area occurs in both sexes and is possibly a modified region of the sole in which prey is held during feeding.

There is an inconspicuous slit along the anterior margin of the foot which is the opening of the anterior mucous gland. The large operculum lies transversely across the foot and the opercular lobes are rather thin and inconspicuous. There are no pallial tentacles.

The dried animal of the holotype of *Z. bodalla* was resuscitated and the head-foot found to agree closely with *Z. australis* except that the sides of the foot are pigmented with black.

TEXT FIGURE 1

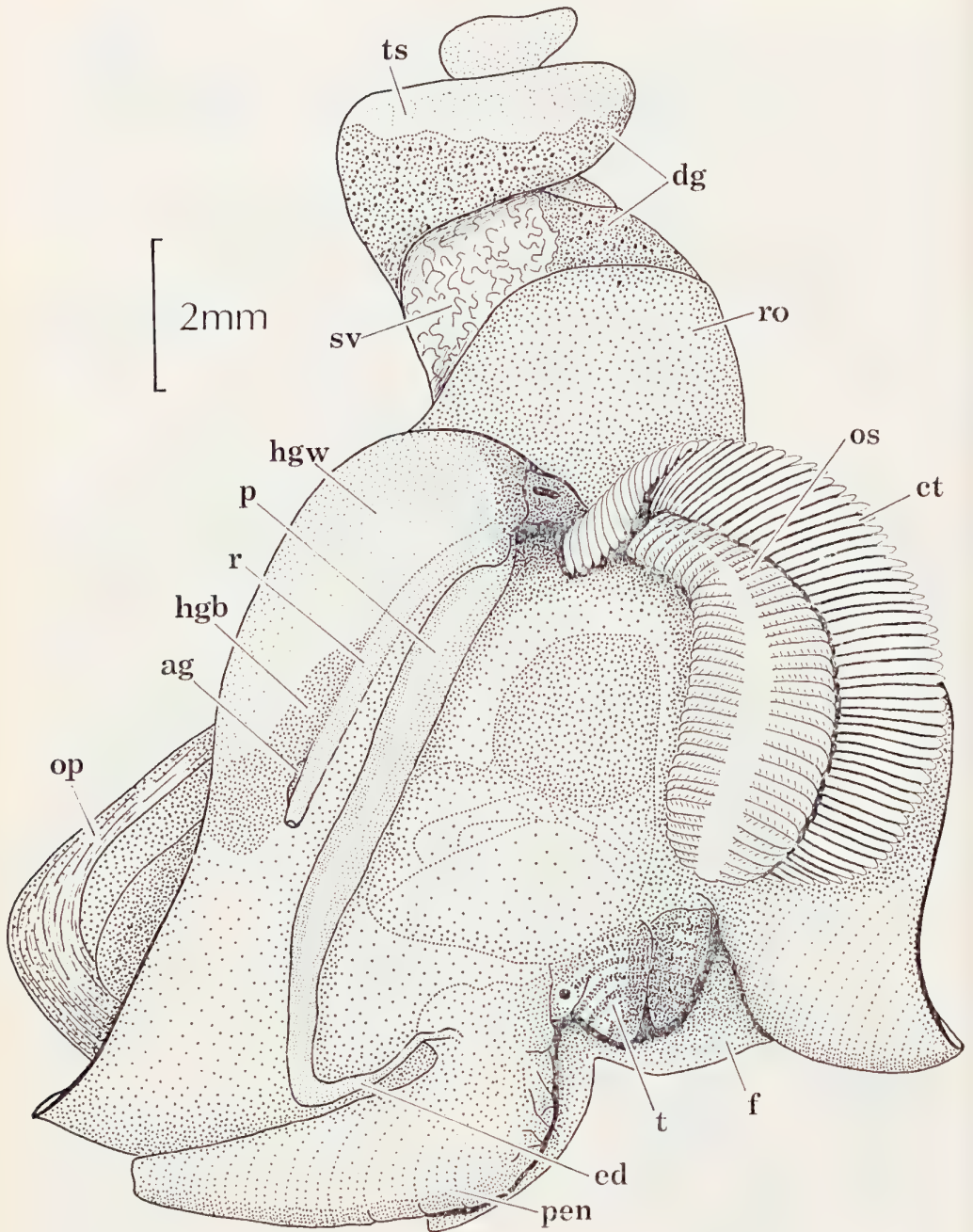
Zemira australis australis (Sowerby)

- a. Ventral view of living animal.
- b. Lateral view of living animal.
- c. Left cephalic tentacle, showing optic lobe.
- d. Radula teeth; one row showing different view of lateral teeth. (Specimen from Malabar, Sydney, N.S.W.)
- e. Operculum (C. 92091).
- f. Anterior alimentary canal.

Zemira bodalla Garrard

- g. Radula teeth; one central and one lateral tooth; from holotype.
- h. Operculum, from holotype.

Block courtesy of F. V. Murray Memorial Fund.



TEXT FIGURE 2

Zemira australis (Sowerby)

Male removed from shell and the mantle cavity opened mid-dorsally.

Block courtesy of F. V. Murray Memorial Fund.

Zemira

Mantle cavity. (Text figure 2.) The broadly triangular mantle cavity contains a very large, long osphradium (os) which has brown leaflets which are secondarily rigid in a latero-ventral direction. The broad central axis is yellowish. The ctenidium (ct) is large, white, with long, narrow filaments. A white hypobranchial gland (hgw) occupies the right posterior part of the mantle cavity roof and the narrow rectum runs along its right edge. The pale brown, thinner part of the hypobranchial gland (hgb) lies next to the anterior end of the rectum and extends further forward than the white region. The hypobranchial secretion is colourless and does not turn purple on exposure to light as has been observed in several neogastropod families. The genital duct lies below the rectum (r) on the right side and the renal organ opens by way of a narrow, horizontal slit into the posterior end of the mantle cavity. There is an extremely short anterior siphon and a very short posterior one, neither of which appears to project beyond the shell margin.

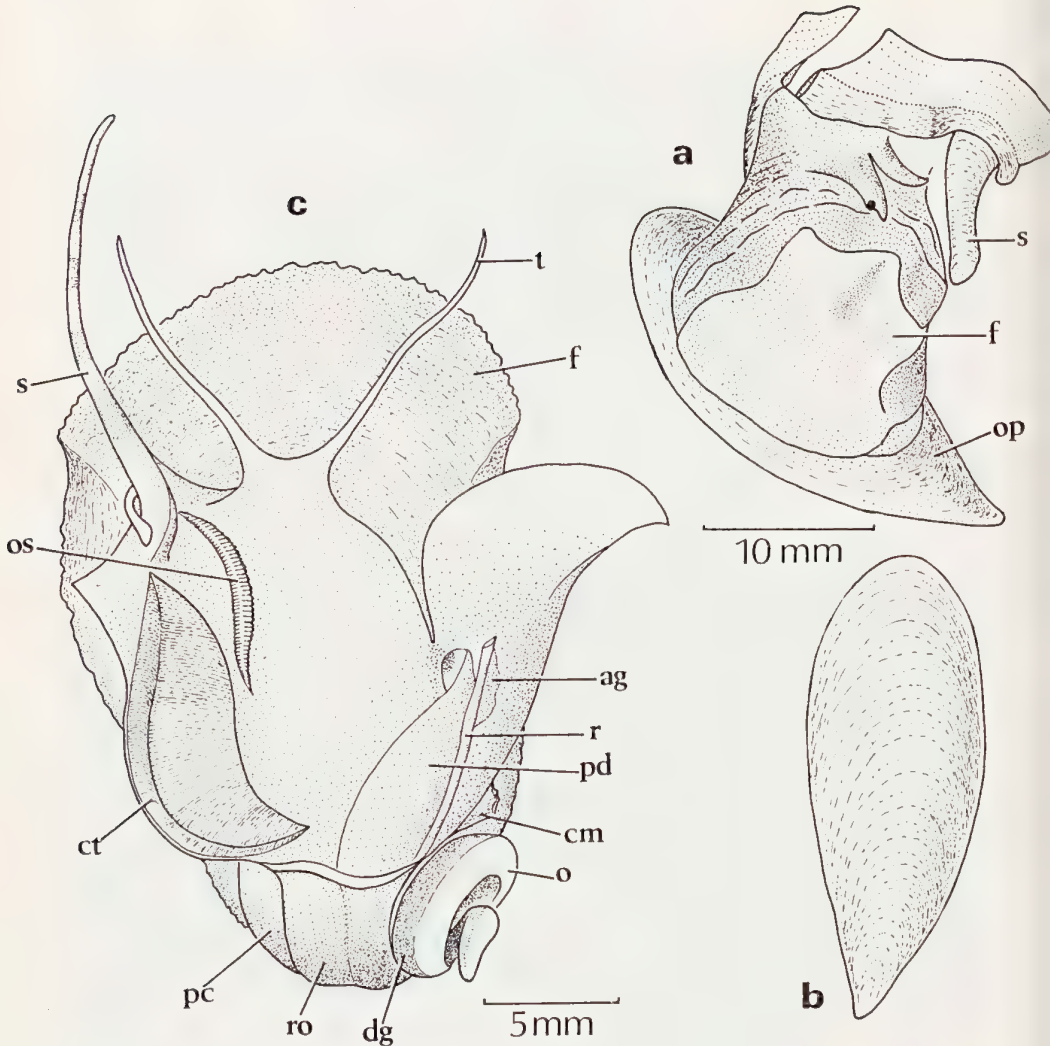
The relative proportions of the ctenidium and osphradium and the edge of the mantle in *Z. bodalla* appears to be similar to those in *Z. australis*.

Alimentary canal. (Text figure 1f.) The proboscis (pr) is very short and broad in its retracted state (it has not been observed extended). The small antero-ventral mouth opens into a large, simple buccal cavity into which the salivary ducts discharge laterally. The anterior oesophagus (ao) runs transversely to the left from the posterior end of the retracted proboscis and the massive pink odontophore (od) is almost totally situated beyond the end of the retracted proboscis. A massive odontophoral retractor muscle (rm) with its origins in the columnellar muscle is attached to the posterior end of the odontophore. The salivary glands (sg) are small and have very short, free ducts which pass into the wall of the short, broad, muscular anterior oesophagus, just in front of the valve of Leiblein. There are no accessory salivary glands. The prominent, pear-shaped valve of Leiblein (vl) has, around its anterior end, a narrow dense-white collar, the rest being translucent white. The remainder of the mid-oesophagus (mo) is short, narrowing rapidly posterior to the valve of Leiblein as it passes through the nerve ring, and then thickens again before reaching the gland of Leiblein (gl). This thicker region of the mid-oesophagus has dense-white, obviously glandular dorsal folds as described in some other Olividae and in the Muricidae. The gland of Leiblein is large, broad, truncated anteriorly and tapers rapidly behind to form a narrow filament.

The stomach closely resembles that of *Oliva sayana* Ravenel, 1834, described by Marcus and Marcus (1959), except that the caecum is relatively a little wider and has finer, more numerous ridges.

The intestine is a rather broad tube which opens at the anus about halfway along the right pallial wall. There is no anal papilla but a short, tubular, brown anal gland (ag) is present.

Radula. (Text figure 1d.) The radula of *Z. australis* has been previously described and figured by Cooke (1918) and Thiele (1929). The central teeth are broad, with 3 upright cusps, the middle one slightly longer than the 2 lateral cusps. The lateral teeth are unicuspid, with broad, heavy bases. The radula of *Z. bodalla* is very similar (fig. 1g) but the cusps on the central teeth are relatively a little longer.



TEXT FIGURE 3

Pseudoliva crassa (Gmelin)

a. Anterior view of animal.

b. Operculum.

Melapium elatum (Schubert & Wagner).

c. Female removed from shell and mantle cavity opened mid-dorsally.

Block courtesy of F. V. Murray Memorial Fund.

Reproductive system. Male (Text figure 2): The testis (ts) is orange-brown in colour and occupies the dorsal part of the visceral coil. A highly convolute seminal vesicle (sv) is situated on the columellar side of the coil. The narrow renal vas deferens opens into a rather narrow prostate (p) which extends along the right side of the pallial cavity and tapers only very slightly from behind to a point at the anterior end of the cavity where it turns horizontally to the base of the penis. This section of the gonoduct, which is highly muscular, is the ejaculatory duct (ed) and it enters the base of the large, broad penis (pen).

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Female: Only the pallial part of the female reproductive tract was studied except to note that the ovary contains large, yolky eggs.

The glandular pallial oviduct is wide and thick, and rather long. It narrows near its anterior end into a muscular vagina which opens into a short muscular bursa copulatrix, circular in transverse section, which lies alongside the anterior portion of the pallial oviduct on its inside wall. The pallial oviduct become thickly glandular behind the end of the bursa, its walls laterally compressed, with a narrow ventral channel separated by a short fold on each side. The glandular oviduct continues more-or-less unchanged to the end of the pallial cavity and then rapidly narrows and terminates. A rather small, bulb-like seminal receptacle (injecting gland?) opens into the ventral channel a little before the posterior end of the glandular oviduct. Egg capsules not known.

Renal organ. The primary and secondary lamellae are separated.

Central nervous system. The ganglia are concentrated and separated by very short connectives as in *Oliva* (Marcus and Marcus, 1959) although the pedal ganglia are relatively a little smaller. The statocysts are large.

Comparison with *Pseudoliva* and *Melapium*

A single specimen of *Pseudoliva plumbea* and one of *Melapium elatum* were available for examination. The former was briefly examined during a visit to the Museum für Naturkunde, E. Berlin.

Melapium (text fig. 3c) shows a simple foot, which lacks a distinct propodium or epipodial outgrowths. It is large and broad and lacks an operculum whereas that of *Pseudoliva* (text fig. 3a) is relatively small and has a large operculum (text fig. 3a, 3b). Unfortunately the hardened animal of *Pseudoliva* did not enable accurate observation of the dorsal anterior end of the foot, although it appeared to be simple. There were no lateral outgrowths. Both species have a distinct, short, longitudinal groove in the anterior part of the sole. *Melapium* has exceedingly long, narrow, cephalic tentacles (t) and no distinct eyes or eye lobes could be determined. *Pseudoliva* has relatively narrow and short cephalic tentacles (t) with the eyes situated about two-thirds distally. Both

Key to lettering in Text figures 1-3

ag	anal gland	pc	pericardium
ao	anterior oesophagus	pd	female pallial genital duct
cm	columellar muscle	pen	penis
ct	ctenidium	pg	pedal "gland"
ed	ejaculatory duct	pr	proboscis
f	foot	ps	proboscis sheath
gl	gland of Leiblein	r	rectum
hgb	hypobranchial gland, brown area	rm	odontophoral retractor muscle
hgw	hypobranchial gland, white area	ro	renal organ
mo	mid-oesophagus	s	siphon
o	ovary	sg	salivary gland
od	odontophore	sv	seminal vesicle
ol	optic lobe	t	tentacle
op	operculum	ts	testis
os	osphradium	vl	valve of Leiblein
p	prostate gland		

PLATE 7



PLATE 7

- 1-2. *Zemira australis* (Sowerby). 15 m. Twofold Bay, N.S.W. (C. 71482). 24.3 x 15.9 mm.
3-4. *Zemira bodalla* Garrard. Holotype. (C. 64798). 26.5 x 17.4 mm.
5. *Pseudoliva crassa* (Gmelin). Port Alexander, West Africa (Museum für Naturkunde, E. Berlin) (dimensions not recorded).
6-7. *Zemira australis antecursoria* subsp. nov. Holotype (P. 33170) 15.1 x 18.5 mm.

Zemira

species have a well-developed anterior siphon (s), that of *Pseudoliva* being blunt whereas the siphon of *Melapium* is long and narrowly tapered.

Of the internal features little was determined. Accessory salivary glands could not be located in either species but their absence cannot be stated with certainty. Both have well developed salivary glands. A very large, dark brown gland of Leiblein was found in *Melapium* but this was small and narrow in *Pseudoliva*.

The ctenidium (ct) is very wide and the osphradium (os) short and narrow in *Melapium* whereas in *Pseudoliva* the osphradium is relatively larger, being about half the width of the ctenidium.

The renal organ in *Melapium* has the renal lamellae separated.

SYSTEMATIC DESCRIPTION

Zemira Adams & Adams, 1853

Eburna (*Zemira*) Adams & Adams, 1853. 1: 110; Chenu, 1859, 1: 164; Tryon, 1881, 3: 101, 203; Tryon, 1883, 2: 152.

Eburnopsis Tate, 1889: 117, Tate, 1894: 174; Cossmann, 1906: 230.

Zemira. Harris, 1897: 167; Hedley, 1899: 118; Cooke, 1918: 12; Thiele, 1929: 331; Wenz, 1943: 1267; Macpherson & Gabriel, 1962: 202.

Latrunculus (*Zemira*). Cossmann, 1901: 141.

Pseudoliva (*Eburnopsis*). Cossmann, 1901: 193; Wenz, 1943: 1269.

Type Species: Monotype: *Eburna australis* G. B. Sowerby 1, 1833.

Shell: With paucispiral protoconch of about $1\frac{1}{2}$ whorls, first whorl broad and dome-like. Teleoconch ovate, usually spirally grooved, spire acuminate, whorls convex, with a tooth on outer lip behind which a prominent spiral groove is impressed on middle of base. Anterior and posterior siphonal notches present but no siphonal canal. Umbilicus moderate to absent.

Radula: Lateral teeth large, unicuspid; central teeth with broad base, tricuspid, simple.

Operculum: Large, oval with nucleus subterminal.

Head-foot: Foot of medium size but small for family, simple, cephalic tentacles short, broad, triangular, with the eyes at their outer bases on wide lobes. Anterior siphon probably does not protrude beyond shell.

Zemira sp.

Pl. 8, fig. 10-11.

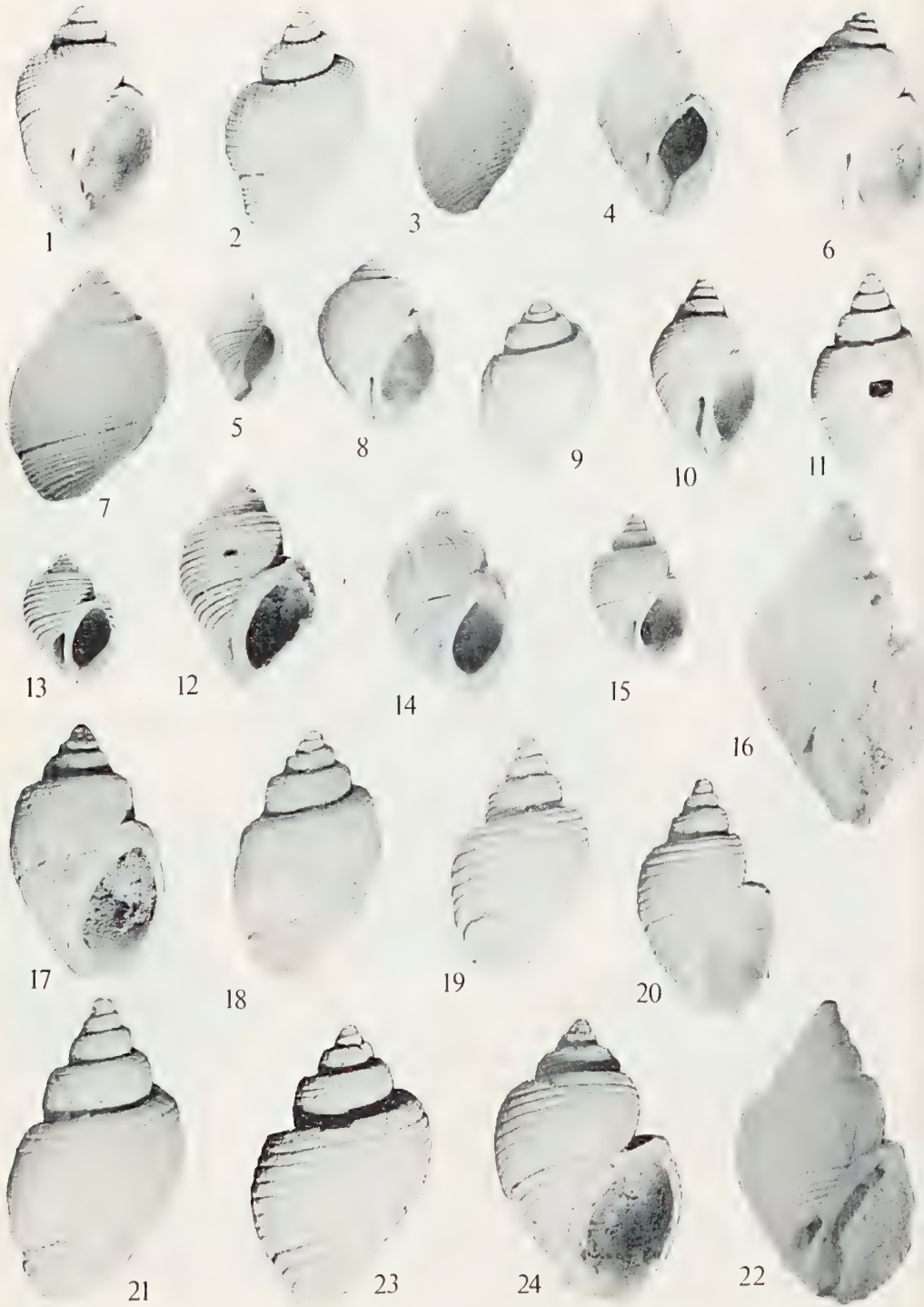
Description: Shell small, fusiform, with spire about $\frac{1}{2}$ the length of the shell. Protoconch of about $1\frac{1}{3}$ whorls, first whorl broad and slightly deviated. Teleoconch with convex whorls, a channelled suture and sculptured with weak spiral grooves on the spire and close spiral cords on the base. Umbilicus rather wide and deep. Apertural features as in *Z. australis*.

Dimensions: Length 14.0 mm. Height of aperture 8.0 mm. Diameter 8.2 mm.

Locality: Glen Aire Clay, FL* 19, Point Flinders, Aire 367098, near Cape Otway, Vic. P. 31291.

*FL—National Museum of Victoria fossil locality number.

PLATE 8



Zemira

Stratigraphic Range: Upper Eocene.

Occurrence: As above.

Material: 2 specimens.

Comments: This species is probably ancestral to *Z. tessellata* but its description will have to await further material. It differs from *tessellata* in the absence of conspicuous axial grooves, in its well-developed umbilicus and relatively shorter aperture.

Zemira tessellata (Tate, 1893)

Pl. 8, fig. 1-5.

Eburnopsis tessellatus Tate, 1893: 174, pl. 11, fig. 10.

Pseudoliva (Eburnopsis) tessellata. Cossmann, 1906, 7: 230, pl. 14, fig. 5.

Description: Shell small, fusiform with a spire about half the length of the shell. Protoconch of about $1\frac{1}{4}$ whorls, the first of which is smooth, somewhat bulbous and slightly deviated at right angles to the axis of the shell. Teleoconch whorls with a grooved suture and sculptured with spiral and axial grooves producing a tessellate pattern. Umbilicus varying in degree of development and frequently absent. Apertural features as in *Z. australis*.

Dimensions:

	Length	Height of aperture	Diameter	
Lectotype T516D	9mm	6mm	6mm	
Hypotype P31167	10	6	6	Ledge, Bird Rock Cliff
Hypotype P31168	11	7	7	Ledge, Bird Rock Cliff

Location of Types: South Australian Museum: Lectotype T516D (Tate's figured specimen is chosen as Lectotype). Paralectotypes T516A - C, E - V, R. Tate Collection.

PLATE 8

Zemira tessellata (Tate)

- 1-4. Jan Juc Formation, Bird Rock Cliffs, Torquay, Vict. FL 24, (P. 31167-8).
 (1-2) 11 x 6 mm.
 (3-4) 10 x 6 mm.

5. Lectotype (T. 516D). 9 x 6 mm.

Zemira australis antecursoria subsp. nov.

- 6-7. Paratype (P. 31174). 17 x 11 mm.
 8-9. Gell'brand Marl, FL. 43 (C. 98573). 12 x 8 mm.

Zemira sp

- 10-11. Glen Aire Clay, Point Flinders, Vict. (P. 31291). 14 x 8 mm.

Zemira australis australis (Sowerby)

12. Muddy Creek, Vict. One of Tate's specimens, marked *Z. praecursoria* var. (T. 517). 24 x 16 mm.
 13. Holotype of *Eburnopsis aulacoessa* Tate (T. 518) 15 x 11 mm.
 14-15. Holotype (14) and paratype (15) of *Z. praecursoria* Tate (T. 520 A-B).
 (14) 22 x 14 mm.
 (15) 17 x 11 mm.
 16. Jemmys Point Formation, FL 123.
 17-18. Rose Hill Marl Member, left bank, Mitchell River on Moondarra Farm, Bairnsdale, Vict. (P. 31295) 18 x 11 mm.
 19-20. Cameron Inlet Formation, Dam on Lot 22, Memana, Flinders Is. 016713, Tasmania (P. 31292). 17 x 10 mm.
 21-22. Jemmys Point Formation, east side of N. Arm below Ferndale Parade, Lakes Entrance, Vict., FL 123. (P. 31294). 22 x 13 mm.
 23-24. Jemmys Point Formation, W side, N. Arm, Lakes Entrance, Vict (P.31293). 20 x 13 mm.

National Museum of Victoria: Hypotype P31167. Hypotype P31168, F. A. Cudmore Collection.

Type Locality: "Spring Creek near Geelong" i.e. FL 24, Bird Rock Cliff below Bird Rock Cap, Torquay, Anglesea 378704. Jan Juc Formation, Janjukian. This species has only been collected in the Jan Juc Formation and not in the overlying strata.

Stratigraphic Range: Janjukian, Upper Oligocene.

Occurrence: Type locality only.

Material: Types and forty topotypes.

Comments: This species is distinguished from others in the genus by its small size and by its tessellate sculpture.

Zemira australis antecursoria subsp. nov.

Pl. 7, fig. 6-7; Pl. 8, fig. 6-9.

Description: Shell globose with a low spire of tumid whorls. Protoconch as in *Z. australis australis*. Spiral sculpture generally of close set fine grooves, but occasionally with other coarse, close set lirae. Axial sculpture absent. Suture grooved or rarely channelled. Umbilicus moderately developed. Apertural features as in *Z. australis australis*.

<i>Dimensions</i> :	<i>Height of</i>		
	<i>Length</i>	<i>aperture</i>	<i>Diameter</i>
Holotype P31170	15.1mm	9mm	10.5mm
Paratype P31174	17	11	11 (FL 35)

Location of Types: National Museum of Victoria: Holotype P31170, pres. A. Monger, 3 June 1965; Paratype P31174, collected K. Bell and T. A. Darragh, 24 Feb. 1970.

Type Locality: FL 43, cutting on Lavers Hill — Cobden Rd. 1.3 km. S of Kennedy's Creek, Princetown 155390. Gellibrand Marl, Batesfordian.

Stratigraphic Range: Longfordian — Batesfordian (Lower Miocene).

Occurrence: Longfordian, FL 28, lower bed, Table Cape; FL 29, upper bed, Table Cape; FL 32, SW. end of Jan Juc Beach; FL 34, S. side of Lake Costin; FL 35, SE. side of Fischers Point.

Batesfordian: FL 38, Curlewis; FL 40, Belmont Shaft; FL 41, Amphitheatre, Yarrowee R; FL 43, Type Locality; FL 46, 0.2 km S. of Kennedy's Creek; FL 48, Bornong Rd. cutting; FL 51, Devils Den, Glenelg River; Caldwell's Cliff, Glenelg River.

Material: Types and nineteen topotypes.

Comments: This subspecies is distinguished from *Z. australis australis* by its low ventricose shape, better developed umbilicus and by the closer spacing of the spiral sculpture. The stratigraphically older specimens tend to have much coarser sculpture than the stratigraphically younger, which suggests derivation of this subspecies from *Z. tessellata*.

Zemira

Zemira australis australis (G. B. Sowerby, I, 1833)

Pl. 7, fig. 1, 2; Pl. 8, fig. 12-24; Text fig. 1a-f, 2.

- Eburna australis* G. B. Sowerby 1, 1833, 20 (8): fig. 5; Reeve, 1849: 5, *Eburna* fig. 4; Küster, 1857: 84 (vol. 3 (1b)); Löbbecke & Kobelt, 1880: 335, pl. 7, fig. 5-8; Kobelt, 1881, 3 (1c): 6, pl. 71, fig. 7-9.
- Eburna (Zemira) australis*. Adams & Adams, 1853, 1: 110; Chenu, 1855, 1: 164, fig. 788; Tryon, 1881, 3: 213, pl. 82, fig. 474; Tyron; 1883, 2: 152, pl. 50, fig. 40.
- Pseudoliva australis*. G. B. Sowerby II, 1859; 3: 73, pl. 216, fig. 7-8.
- Zemira praecursoria* Tate, 1888: 163, pl. 11, fig. 5; Harris 1897: 167.
- Eburnopsis aulacoessa* Tate, 1889: 117, pl. 5, fig. 3.
- Zemira australis*. Hedley, 1899: 118; Cooke, 1918: 12, text fig; Thiele, 1929, 1 (1): 331, fig. 380-82; Macpherson & Gabriel, 1962: 202, fig. 241; Wilson & Gillett, 1971: 108, pl. 71, fig. 9, 8a.

Description: Shell ovate with a high gradate spire. Protoconch of $1\frac{1}{4}$ smooth whorls, the first of which is globose and slightly deviated at right angles to the axis of the shell, pale fawn or whitish. Axial sculpture absent. Spiral sculpture generally of well spaced fine grooves present over the spire whorls and body whorl, but frequently absent from the posterior slope of the body whorl and occasionally with prominent, wide deep grooves giving the body whorl a corded appearance. Suture generally set in a deep wide channel but occasionally set merely in a groove. Aperture oval with a shallow posterior groove and anteriorly a notch which is not produced anteriorly into a siphon but is merely a groove between the end of the columella and the outer lip. Columella regularly concave, smooth, the inner lip slightly thickened. Outer lip with a short spine in its anterior half from which a prominent groove runs around the body whorl and is coincident with the suture. Umbilicus generally poorly developed or absent. Colour pale pinkish fawn with dark brown blotches on the shoulder which become irregular zigzag streaks or dots and splashes of brown on the remainder of the body whorl. A second, more inconspicuous row of blotches occurs around the basal groove. Aperture with pinkish white lips and fawn within. Periostracum very thin, yellowish and usually worn off.

Operculum (fig. 1e) large, filling the aperture, with a subterminal nucleus a little inside the anterior end; columellar side slightly thickened with a weak, narrow ridge close to the edge; growth-lines regular, concentric, close set and crossed by equally strong, close radial sculpture with raised narrow, scalelike processes at the points of intersection.

Dimensions:	Length	Height of aperture	Diameter
C 7148	24.3mm	15.8mm	15.9mm
T 518	15	10	11
T 520A	22	13	14
T 517	24	13	16

Location of Types: Holotype could not be located in British Museum (Natural History), pers. comm., K. Thomas.

South Australian Museum: Holotype of *Eburnopsis aulacoessa*, T518; Holotype of *Zemira praecursoria*, T. 520A, R. Tate Collection.

Type Locality: "New South Wales".

Stratigraphic Range: Balcombian (Middle Miocene) — Recent.

Occurrence: Living: Ballina, northern New South Wales (Australian Museum, C. 5125) to Western Port, Victoria (Australian Museum, C. 56720), the islands of Bass Strait and Tasmania. It normally lives in the deeper sublittoral (from about 12m) and down to about 137m on fine to coarse sandy substrate.

Fossil: FL 82, Clifton Bank, Muddy Creek; FL 83, Muddy Creek Fm. at MacDonalds Bank; FL 87, Lake Bullenmerri; FL 89, Y.A.L. Quarry, Curdies; FL 93, Rutledges Beach; FL 102, Warramine Creek; FL 103, downstream section, Gunyoung Creek; FL 104, Manyung Rocks; FL 108, Driers, Mitchell River; FL 111, Rose Hill; FL 116, N end of Lake Bunga; FL 122 N Arm, S of Hunter gully; FL 123, N Arm, below Ferndale Parade; FL 124, N Arm S of Hunter Gully; FL 137, Forsythes bank; FL 139, Macdonalds bank; Dam on Lot 47, Memana, Flinders Is. 022631, Tasmania; Dam on Lot 22, Memana, Flinders Is. 016713, Tasmania.

Comments: Many authors have dated this species as 1841, the date given on the frontispiece of *The Conchological Illustrations*. However, this work was published in a series of separate parts over several years and Shaw (1909) has given the date of publication of part 20, the *Eburna* Catalogue and plate as 1833.

Unlike living specimens the fossils are extremely variable in form and sculpture, (see Plate 8), ranging from relatively smooth forms (fig. 21, 22), such as the type of *Z. praecursoria* (fig. 14) to heavily ridged forms such as the type of *Eburnopsis aulacoessa* (fig. 13) and others (e.g. fig. 12, 19, 20, 23, 24). Intermediate sculptural forms are common (fig. 16). Some fossil populations, such as that at Rose Hill (fig. 17-18), have no prominent sutural channel whereas others, such as that at Lake Bullenmerri, have specimens with no sutural channel together with specimens with prominent channels and all grades between these two extremes. The presence of strong spiral sculpture is not correlated with the strength of the sutural channel (cf. fig. 12, 19, 20, with 23, 24) nor is it related to umbilical development (cf. fig. 12, 19, 20, 23, 24 with 13). There appears to be no geographic or stratigraphic correlation with this morphological variation. Living populations of *Z. australis* which tend to be much more constant in form and sculpture than fossil ones, fall within the range of variation of *Z. praecursoria* and therefore we consider the latter to be a synonym, since *Z. australis* has priority. *Eburnopsis* is a synonym of *Zemira*, since the type species of the former is merely a heavily ridged specimen of *Z. australis* as mentioned above.

Zemira bcdalla Garrard, 1966

Pl. 7, fig. 3, 4; Text fig. 1 g-h.

Zemira bodalla Garrard, 1966: 5, pl. 1, fig. 8.

Description: Shell similar to *Z. australis australis* but larger with stronger and more widely spaced spiral grooves and a more prominent umbilicus than in Recent *australis*. Colour white, the spiral cords brown, broken only by occasional narrow, white axial streaks.

Protoconch brown. Operculum (damaged) similar to that of *Z. australis* but with no radial sculpture (fig. 1h). Radula with cusps on the central teeth a little longer than in *Z. australis australis* (fig. 1g).

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Dimensions:	Length	Height of aperture	Diameter
Holotype C64796	26.5mm	18mm	17.4mm
Paratype F26649	25	16	17

Location of Types: Australian Museum, Sydney: Holotype C64798 and 4 paratypes (C71483 (3), C72043 (1)), National Museum of Victoria, 1 paratype (F 26649).

Type Locality: 146 m, 29 km NNE. of Cape Moreton, due E of Caloundra, Queensland.

Occurrence: Type locality only.

Material: Type and 5 paratypes.

Comments: Some fossil specimens of *Z. australis australis* (e.g. Pl. 8, fig. 23, 24) approach this species in sculptural and other characteristics and it may be that *Z. bodalla* is a deep water derivative of such a population. There is little doubt that the two Recent forms are separate species although the amount of material at hand is small. The difference in the operculum and the pigmentation of the head-foot re-inforce the evidence of the shell features in the supposition that *bodalla* and *australis* are distinct species.

DISCUSSION

The anatomical information presented does not entirely clarify the familial position of *Zemira australis*. The simple foot, lack of a well-developed anterior siphon and accessory salivary glands are features discordant with other members of the Olividae, such as *Ancilla*, *Oliva* and *Olivella* (Marcus & Marcus, 1959, 1968), although *Melapium* also has a simple foot and may lack accessory salivary glands.

The anatomy of the alimentary canal of the Olividae and Muricidae is rather similar and differs from most other neogastropod groups in usually having glandular dorsal folds in the mid-oesophagus, a prominent valve of Leiblein and a large, simple gland of Leiblein. The pallial cavity of the two families differs mainly in its shape, being modified in the Olividae because of the long, narrow aperture, and in this respect *Zemira* is more similar to the Muricidae. The hypobranchial secretion generally turns purple when exposed to light in the Muricidae but not in the Olividae or in *Zemira*.

As Cooke (1918) found, the radula is similar to that of both the Muricidae and the Olividae.

The head tentacles are pattered and short and much more like those of *Ancilla* (Marcus & Marcus, 1968) than those of *Oliva* or *Olivella* (Marcus & Marcus, 1959). The lateral lobes which contain the eyes are unlike any structure described in the Olividae but resemble those of some volutes. *Pseudoliva* has the eye lobes and tentacles fused into a single conical structure.

The renal organ is like that of other members of the Olividae and is unlike that seen in the Muricidae.

The Pseudolivinae as shown by Wenz (1941) contains a number of genera which include, among others, *Pseudoliva* Swainson, 1840, and

Fulmentum Fischer, 1884, both of which resemble *Zemira* in shell features, although *Pseudoliva* is known to have a different operculum with a terminal nucleus, that of *Zemira* having the nucleus subterminal, and the periost-racum of *Pseudoliva* is well developed (see Pl. 7, fig. 5) whereas it is exceedingly poorly developed in *Zemira*. *Fulmentum sepimentum* (Rang, 1832) has an operculum with a terminal nucleus as shown in a figure by Nickles (1950).

The radula of *Pseudoliva crassa* (Gmelin), the type species of *Pseudoliva*, has been figured by Thiele (1929) and shown to have 2 cusps on the lateral teeth and 3 on the central tooth. *Sylvanocochlis* Melvill, 1889, is closely related to *Pseudoliva* and Barnard (1959) describes the radula of the type species, *S. ancilla* (Hanley, 1859) which is very similar to that of *Pseudoliva*. The radula of these two species therefore differs somewhat from that of *Zemira* but as there is quite a lot of radular variation in the Olividae this may not be important. Barnard also gives some details of the colour of the foot of *S. ancilla* but unfortunately does not describe its shape. He also states that the "siphon (is) closely ringed with black". Knowledge of the shape of the foot in particular of *Pseudoliva* could be of considerable importance in determining whether or not *Pseudoliva* and *Zemira* were actually closely related, although Barnard's indication that *Sylvanocochlis* has a siphon suggests that *Zemira* and the genera more closely related to *Pseudoliva* may show at least some important external differences.

Because of the great differences in the foot between *Zemira* and the typical members of the Olividae, it is clear that *Zemira* requires at least subfamilial separation. With only scant information about the animals of the African genera and species placed in the Pseudolivinae an accurate assessment of the relationships of these animals and of *Zemira* is impossible. On the available evidence, it is recommended that *Zemira* continue to be tentatively placed in the Pseudolivinae within the Olivinae.

The earliest occurrence of *Zemira* in the fossil record is based on two unnamed specimens from the Upper Eocene Glen Aire Clay at Point Flinders, Victoria. It has the overall features of *Z. australis* but its shape is more like that of *Z. tessellata*, of which it is the probable ancestor. The umbilicus is, however, well developed and the shell bears a close resemblance to *Buccinorbis vetusta* Conrad from the Eocene of the Eastern United States. The latter has apertural features somewhat akin to *Zemira*, and this, together with the presence of a wide umbilicus in the Glen Aire Clay specimens, suggest that *Zemira* and *Buccinorbis* are closely related, as originally implied by Cossmann (1901: 193), who placed both *Z. praecursoria* and *Z. tessellata* in *Buccinorbis*, which he regarded as a subgenus of *Pseudoliva*. On shell characters *Buccinorbis* does seem to be related to *Pseudoliva*. The palaeontological evidence therefore supports the tentative assignment of *Zemira* to the Pseudolivinae.

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